FINAL TECHNICAL REPORT

Title: Exploration of Neural Process and Language Performance
(Research Opportunities for Program Officers)

ONR ROPO Grant No: N00014-97-1-0415

Sponsor: University of Maryland, Dept. of Computer Science

Program Officer: Helen M. Gigley (ONR Code 342)

University of Maryland PI: James A. Reggia

Summary:

This ROPO deals with cognitive modeling of brain processes and language comprehension. Previously, we were continuing work within the HOPE architecture, a model that was developed based on observed human performance under normal and lesioned conditions (studying aphasic patients). It was the first time-based model of on-line sentence comprehension based on neural processes. Within the working group at UMD, emphasis shifted to look at modeling of hemispheric cooperation in processing. The ROPO emphasis was shifted to be consistent with this effort as there is extensive interest in the group that is focusing on language related matters.

Progress During 1998

During this academic year, I have shared the cost of a student with Dr. Reggia. The student got up to speed on modeling skills and working on a model of corpus callosum function to be applied to several different tasks. In simulations during this past year, we have clearly demonstrated the viability of the proposed work. Our model was trained to generate the correct sequence of phonemes for 50 monosyllabic words (simulated reading aloud) under a variety of assumptions about hemispheric asymmetries and callosal effects. After training, the ability of the full model and each hemisphere acting alone to perform this task was measured. Lateralization occurred readily toward the side having larger size, higher excitability, or higher learning rate parameter. Lateralization appeared most readily and intensely with strongly inhibitory callosal connections, supporting past arguments that the effective functionality of the corpus callosum is inhibitory. Many of the results are interpretable as the outcome of a "race to learn" between the model's two hemispheric regions, leading to the concept that asymmetric hemispheric plasticity is a critical common causative factor in lateralization. To our knowledge, this is the first computational model to demonstrate the effects of callosal lesioning on lateralization of function, and it suggests that such models can be useful in better understanding the mechanisms of cerebral lateralization.

Technical Description

At the 1995 conference on Neural Modeling of Cognitive and Brain Disorders held at the University of Maryland, it became apparent that recent advances have begun to raise questions which the HOPE model had previously discussed in the early 1980's. Viewing the brain as a signal processing system that relies on synchronization of processing in an information sense can now be accepted as a possible view providing explanation that includes both within patient performance variations and across population performance phenomena. There are now many researchers who are using a modeling approach to study the performance of persons with brain disorders to determine their effect on performance. Several have found evidence that the sequential properties of information load effect performance.

With these findings, and because of the evidence that the neural hemispheres work in collaboration, the role of the corpus callosum as mediating this collaboration is becoming recognized. This effort intends to initiate new modeling techniques to investigate and hypothesize how it might operate in these processes. The specific aims of the proposed research were 1) to develop computer models of hemispheric interactions and asymmetries, using them to systematically study factors influencing lateralization of function, and 2) to study the effects of acute focal lesions in these models, determining factors influencing recovery. Thus, this work introduced a new computational approach to studying hemispheric specialization that complements more traditional human and animal experimental work. The neural models created in this research consisted of paired, interconnected hemispheric regions involving a linguistic task. Although simplified from biological reality, these computational models are based on generally accepted principles of cortical connectivity, dynamics and plasticity. They were used to examine which of several contemporary hypotheses about the biological mechanisms of hemispheric specialization produce functional lateralization when tested in a detailed computational brain model. Specifically, we examined asymmetries in the size, connectivity, excitability, plasticity, etc. of model hemisphere regions and different assumptions about the role of the corpus callosum (inhibitory versus excitatory, etc.). Selected versions of these models were subjected to simulated acute focal lesions of varying sizes in the corpus callosum to assess which model assumptions and lesions led to transcallosal diaschisis. Particular emphasis was placed on identifying model features that maximized post-lesion recovery. To our knowledge, this is the first attempt to develop computational models of hemispheric specialization and transcallosal diaschisis.

This award also allowed Dr. Gigley to participate in the annual Academy of Aphasia Meeting, and to attend the 1998 Workshop on Neural Models of Brain and Cognitive Disorders.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
1/15/99

3. REPORT TYPE AND DATES COVERED
Final Technical Report

4. TITLE AND SUBTITLE
Computational Linguistics in Interactive Communication

5. FUNDING NUMBERS
N000149710415

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of Naval Research
Ballston Centre Tower One
800 North Quincy Street
Arlington, VA 22217

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Unrestricted

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Under this ROPO grant, Dr. Reggia provided a unique opportunity to participate with his graduate team who are studying various aspects of recovery of function using computational neural models. The stimulating environment provided many opportunities to find out about new approaches in studying brain processing. Further participation in attending related meetings, the Academy of Aphasia and both meetings organized by Dr. Reggia at the University, 1995 and 1998, Neural Modeling of Cognitive and Brain Disorders, provided bridges to the broader research community. Three graduate students were trained in LISP while re-implementing the HOPE model. Difficulties with the output control restricted our ability to run experiments on it at the end. A unique opportunity to share a graduate student computationally modeling word reading enabled us to develop a model of language lateralization. The University setting provided an environment for quiet study as well as intellectual exchange in these fields.

14. SUBJECT TERMS
neural modeling, language

15. NUMBER OF PAGES
2

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR